Injury and Illness Casualty Distributions Among U.S. Army and Marine Corps Personnel during Operation Iraqi Freedom

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Injury and Illness Casualty Distributions among U.S. Army and Marine Corps Personnel during Operation Iraqi Freedom

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ABSTRACT The objective of this study was to evaluate the distributions of U.S. Marine Corps and Army wounded in action (WIA) and disease and nonbattle injury (DNBI) casualties during Operation Iraqi Freedom Major Combat Phase (OIF-1) and Support and Stability Phase (OIF-2). A retrospective review of hospitalization data was conducted. χ^2 tests were used to assess the Primary International Classification of Diseases, 9th Revision (ICD-9), diagnostic category distributions by phase of operation, casualty type, and gender. Of the 13,071 casualties identified for analysis, 3,263 were WIA and 9,808 were DNBI. Overall, the proportion of WIA was higher during OIF-1 (36.6%) than OIF-2 (23.6%). Marines had a higher proportion of WIA and nonbattle injuries than soldiers. Although overall DNBI distributions for men and women were statistically different, their distributions of types of nonbattle injuries were similar. Identifying differences in injury and illness distributions by characteristics of the casualty population is necessary for military medical readiness planning.

INTRODUCTION

Examining and understanding the distribution of combat casualty illnesses and injuries is essential to improving military medical planning. Reliable estimates of casualties and threats to the Health Service Support (HSS) system, such as mass casualty situations, are necessary to forecast medical resource requirements for military operations. Casualty estimates consist of absolute numbers, surges in casualty admissions, evacuation patterns, and the distribution of types of injuries and illnesses. Hospitalization estimates and other support requirements are derived from these data and are then incorporated into HSS planning tools, such as the Medical Analysis Tool (MAT),[1] Estimating Supplies Program,[2] and Tactical Medical Logistics Planning Tool.[3]

MAT is a joint medical resource planning tool that provides theater-wide medical and clinical decision support during planning, programming, and deployment. MAT also provides medical planners with the level and scope of medical support needed for a joint operation, and the capability of evaluating probable courses of action for a variety of scenarios. The Estimating Supplies Program and the Tactical Medical Logistics Planning Tool are the planning tools used by the Marines and Navy to estimate and configure the authorized medical allowance lists, provide overall medical system analysis, and assist in risk assessment and capability-based planning.

The purpose of the present study was to describe the distribution of evacuated wounded in action (WIA) and disease and nonbattle injury (DNBI) casualties sustained during the Major Combat Phase (OIF-1) and the Support and Stability Phase (OIF-2) of Operation Iraqi Freedom (OIF) involving the U.S. Army and Marines.

This study uses data from the TRANSCOM Regulating and Command and Control Evacuation System (TRAC2ES) and the Joint Patient Tracking Application (JPTA). TRAC2ES is a World Wide Web-based system that provides documentation on patient regulation and movement for all branches of the U.S. Armed Forces in the theater of operations. The JPTA is a World Wide Web-based patient tracking and management tool that collects, manages, analyzes, and reports data on patient transfers, and provides information about transportation, treatment, and disposition of patients from Operations Iraqi and Enduring Freedom. The data from the JPTA became available after January 2004.

Both systems are part of the Theater Medical Information Program—Joint (TMIP-J).[4] TMIP-J is a family of systems designed to aid deployed medical personnel in all levels of care in theater, including complete clinical care documentation, medical supply and equipment tracking, patient movement visibility, and health surveillance.

METHODS

A retrospective review of hospitalization ICD-9 (Primary International Classification of Diseases, 9th Revision) data from OIF was performed. Data from OIF-1 (March 21–April 30, 2003) were obtained from TRAC2ES. Data from OIF-2 (March 1, 2004–April 30, 2005) were obtained from JPTA.[5]

Primary ICD-9[6] diagnoses, gender, and service were extracted from the respective databases for each patient. Casu-

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alties were categorized as WIA or DNBI and were assigned to an ICD-9 diagnostic category (or injury subcategory) based on their primary diagnosis on admission. Since the majority of WIA and nonbattle injury causalities were from the injury and poisoning category (ICD-9 codes 800–999), these diagnoses were classified into the injury and poisoning subcategories (i.e., fractures (800–829), dislocations (830–839), sprains and strains (840–849), burns (840–849), intracranial injury (850–854), open wounds (870–879)) based on the casualty trauma description. In addition, "amputations" were included as a unique category to parallel previous studies that examined injury distributions.[7–9] Furthermore, two ICD-9 disease categories, "nervous system" and "musculoskeletal," were added to the injury distribution to capture: (1) injuries coded as disease in ICD-9 (e.g., ICD-9 code 388.11, acoustic trauma (explosive) to ear); (2) injuries miscoded as diseases (e.g., injuries to the eye); and (3) future conditions resulting from injury (e.g., a Marine whose back was injured in combat and continues to seek medical care for back pain). Excluding these situations would eliminate a significant portion of injury-related causalities.

WIA casualties were defined as active duty military personnel who were injured during hostile action and required hospitalization. Casualties who were killed in action (i.e., died as a result of hostile action before reaching a medical treatment facility), died of wounds (i.e., died as a result of wounds received during hostile action after reaching a medical treatment facility), or returned to duty were excluded from analysis. Subcategories within the injury ICD-9 category (e.g., fractures, amputations) were used to compare WIA casualties. DNBI casualties were defined as active duty military personnel who required hospitalization due to disease or injury unrelated to a hostile event. DNBI casualties were compared across 17 ICD-9 diagnostic groups.

χ^2 tests of independence were used to compare the diagnostic distributions (using the ICD-9 diagnostic categories) of WIA and DNBI casualties by phase of operation, branch of service, and gender. Statistical analyses were performed using SPSS software version 12.0.2 (SPSS Inc., Chicago, Illinois); tests were two-tailed and $p \leq 0.05$ was used to determine statistical significance. Adjusted standardized residuals were used to identify cells that had the greatest impact on the χ^2 statistic. Critical values for standardized residuals were $\pm$ 2.0.

RESULTS

Of the 13,071 casualties identified for analysis, 1,368 (10.5%) were from OIF-1 and 11,703 (89.5%) were from OIF-2. As shown in Table I, the majority of casualties were DNBI (75.0%), were Army personnel (83.5%), and were male (90.0%).

Phase of Operation

The overall injury distributions among WIA casualties from OIF-1 were statistically different from that of OIF-2 (χ^2 = 60.77, $df = 9$, $p < 0.001$). There were a higher proportion of WIA casualties during OIF-1 than OIF-2 (36.6% vs. 23.6%).

TABLE I. Characteristics of U.S. Marine and Soldier Casualties during OIF-1 and OIF-2

	OIF-1		OIF-2		Total	
Characteristic	No.	%	No.	%	No.	%
Casualty type						
DNBI	867	63.4	8,941	76.4	9,808	75.0
WIA	501	36.6	2,762	23.6	3,263	25.0
Branch of service						
Army	915	66.9	9,998	85.4	10,913	83.5
Marine Corps	453	33.1	1,705	14.6	2,158	16.5
Gender						
Male	1,255	91.7	10,511	89.8	11,766	90.0
Female	113	8.3	1,192	10.2	1,305	10.0
Total	1,368	100.0	11,703	100.0	13,071	100.0

TABLE II. Distribution of WIA Casualties by Injury Category during OIF-1 and OIF-2[a]

	OIF-1		OIF-2		Total	
Injury Category	No.	%	No.	%	No.	%
Amputations	12[b]	2.4	132[c]	4.8	144	4.4
Burns	20	4.0	163	5.9	183	5.6
Dislocations	11[c]	2.2	23[b]	0.8	34	1.0
Fractures	111[b]	22.2	845[c]	30.6	956	29.3
Intracranial	7	1.4	72	2.6	79	2.4
Nervous system[d]	13	2.6	95	3.4	108	3.3
Sprains/strains	23[c]	4.6	42[b]	1.5	65	2.0
Musculoskeletal	20	4.0	69	2.5	89	2.7
Open wounds[e]	240[c]	47.9	1,087[b]	39.4	1,327	40.7
Other	44	8.8	234	8.5	278	8.5
Total	501	100.0	2,762	100.0	3,263	100.0

[a] $\chi^2 = 60.77$, $df = 9$, $p < 0.001$.
[b] Adjusted standardized residual was less than −2.0.
[c] Adjusted standardized residual was more than +2.0.
[d] Hearing and visual impairment.
[e] Excludes amputations.

As indicated by the adjusted standardized residuals (see Table II), sprains and strains, open wounds, and dislocations were significantly higher during OIF-1, whereas burns, fractures, and traumatic amputations were higher during OIF-2.

As demonstrated in Table III, ICD-9 category distributions for DNBI casualties also differed significantly by phase of operation (χ^2 = 187.86, $df = 16$, $p < 0.001$). Injuries and mental disorders were notably higher during OIF-1. During OIF-2, infectious and parasitic diseases and diseases of the musculoskeletal, digestive, and nervous systems were more common.

Branch of Service

Marines sustained proportionally more WIA injuries than Army personnel during OIF-1 (51.9% vs. 29.1%) and OIF-2 (54.1% vs. 18.4%). In addition, distributions of injury categories among WIA casualties differed significantly between Army and Marines during OIF-1 (χ^2 = 27.87, $df = 9$, $p < 0.01$) and during OIF-2 (χ^2 = 27.28, $df = 9$, $p < 0.01$) (Table IV).

TABLE III. Distribution of DNBI Casualties by ICD-9 Diagnostic Category during OIF-1 and OIF-2[a]

	OIF-1		OIF-2		Total	
ICD-9 Category	No.	%	No.	%	No.	%
Infectious	7[b]	0.9	175[c]	1.9	182	1.9
Neoplasms	7	1.5	141	1.6	148	1.5
Endocrine	10	1.3	165	1.8	175	1.8
Blood	2	0.2	13	0.2	15	0.2
Mental disorders	66[c]	7.9	501[b]	5.6	567	5.8
Nervous system	38[b]	4.3	556[c]	6.2	594	6.1
Circulatory	32	4.0	409	4.6	441	4.5
Respiratory	34	3.7	250	2.8	284	2.9
Digestive	66[b]	7.1	1,005[c]	11.2	1,071	10.9
Genitourinary	52	5.8	563	6.3	615	6.3
Pregnancy	13[c]	1.5	38[b]	0.4	51	0.5
Skin	20	2.3	251	2.8	271	2.8
Musculoskeletal	89[b]	10.8	1,716[c]	19.2	1,805	18.4
Congenital	6	0.8	51	0.6	57	0.6
Ill-defined	75	9.2	958	10.7	1,033	10.5
Injury	338[c]	37.4	1,978[b]	22.1	2,316	23.6
Supplementary	12	1.4	171	1.9	183	1.9
Total	867	100.0	8,941	100.0	9,808	100.0

[a] $\chi^2 = 187.86$, $df = 16$, $p < 0.001$.
[b] Adjusted standardized residual was less than −2.0.
[c] Adjusted standardized residual was more than +2.0.

The distributions of DNBI ICD-9 categories by service and phase of operation are shown in Table V. Marines had the highest proportions of nonbattle injuries during OIF-1 and OIF-2, and the lowest proportions of ill-defined conditions, mental disorders, and diseases of the musculoskeletal system. However, χ^2 tests were not performed on the DNBI distributions by phase and service due to the lack of cell counts in several of the ICD-9 categories.

Gender

Disease and nonbattle injury ICD-9 casualty distributions also differed by gender ($\chi^2 = 201.90$, $df = 15$, $p < 0.001$) (Table VI). The proportion of nonbattle injuries was significantly higher among men than women (25.2% vs. 16.4%). However, among the ICD-9 major categories, neoplasms, mental disorders, diseases of the blood and blood-forming organs, respiratory, and genitourinary systems were more common among women than men. As shown in Table VII, the gender distributions within each phase were consistent with the overall findings for gender.

Although male and female DNBI distributions were different, similar trends existed among them. Restricting our analysis to just the ICD-9 injury and poisoning group demonstrated that the distributions of nonbattle injuries among men and women were similar ($\chi^2 = 5.62$, $df = 6$, $p = 0.47$) (Table VIII).

DISCUSSION

This study evaluated the diagnostic distributions of WIA and DNBI casualties from the Major Combat and Support and Stability Phases of OIF obtained from the reporting tools of the TMIP-J program. As in previous military operations, DNBI casualties were much more prevalent than WIA casualties overall.[10] However, during both phases of OIF, Marines sustained a significantly higher proportion of WIA casualties than the Army; approximately one in two Marine casualties was WIA compared with only one in five Army casualties. This difference may be attributed to the distinct doctrinal missions and capabilities of the Marines Corps and the Army.

The discrepancy in wounding patterns among battle casualties in the present analysis—more traumatic amputations, fractures, and burns during OIF-2—is likely the result of changing weaponry preferences of the enemy. During OIF-2, improvised explosive devices emerged as the primary mechanism of injury among WIA casualties.[11] In previous conflicts, including OIF-1, however, injuries due to small arms weapons were more common.[12,13]

TABLE IV. Distribution of U.S. Army and Marine Corps WIA Casualties by Injury Category during OIF-1 and OIF-2

	OIF-1[a]				OIF-2[b]			
	Army		Marine Corps		Army		Marine Corps	
Injury Category	No.	%	No.	%	No.	%	No.	%
Amputations	4	1.5	8	3.4	99[c]	5.4	33[d]	3.6
Burns	13	4.9	7	3.0	121[c]	6.6	42[d]	4.6
Dislocations	5	1.9	6	2.6	16	0.9	7	0.8
Fractures	59	22.2	52	22.1	540	29.4	305	33.0
Intracranial	1[d]	0.4	6[c]	2.6	42	2.3	30	3.3
Nervous system	9	3.4	4	1.7	74[c]	4.0	21[d]	2.3
Sprains/strains	14	5.3	9	3.8	26	1.4	16	1.7
Musculoskeletal	12	4.5	8	3.4	47	2.6	22	2.4
Open wounds	113[d]	42.5	127[c]	54.0	701	38.1	386	41.8
Other	36[c]	13.5	8[d]	3.4	173[c]	9.4	61[d]	6.6
Total	266	100.0	235	100.0	1,839	100.0	923	100.0

[a] $\chi^2 = 27.87$, $df = 9$, $p < 0.01$.
[b] $\chi^2 = 27.28$, $df = 9$, $p < 0.01$.
[c] Adjusted standardized residual was more than +2.0.
[d] Adjusted standardized residual was less than −2.0.

TABLE V. Distribution of DNBI Casualties by ICD-9 Diagnostic Category and Branch of Service during OIF-1 and OIF-2

	OIF-1				OIF-2			
	Army		Marine Corps		Army		Marine Corps	
ICD-9 Category	No.	%	No.	%	No.	%	No.	%
Infectious	6	0.9	1	0.5	162	2.0	13	1.7
Neoplasms	7	1.1	0	0.0	132	1.6	9	1.2
Endocrine	5	0.8	5	2.3	155	1.9	10	1.3
Blood	2	0.3	0	0.0	13	0.2	0	0.0
Mental disorders	58	8.9	8	3.7	457	5.6	44	5.6
Nervous system	31	4.8	7	3.2	496	6.1	60	7.7
Circulatory	24	3.7	8	3.7	392	4.8	17	2.2
Respiratory	30	4.6	4	1.8	237	2.9	13	1.7
Digestive	41	6.3	25	11.5	929	11.4	76	9.7
Genitourinary	39	6.0	13	6.0	527	6.5	36	4.6
Pregnancy	11	1.7	2	0.9	37	0.5	1	0.1
Skin	13	2.0	7	3.2	222	2.7	29	3.7
Musculoskeletal	76	11.7	13	6.0	1,619	19.8	97	12.4
Congenital	5	0.8	1	0.5	48	0.6	3	0.4
Ill-defined	63	9.7	12	5.5	893	10.9	65	8.3
Injury	226	34.8	112	51.4	1,682	20.6	296	37.9
Supplementary	12	1.8	0	0.0	158	1.9	13	1.7
Total	649	100.0	218	100.0	8,159	100.0	782	100.0

χ^2 tests were excluded due to insufficient cell counts.

TABLE VI. Distribution of DNBI Casualties by Gender and ICD-9 Diagnostic Category during OIF[a]

	Men		Women		Total	
ICD-9 Category	No.	%	No.	%	No.	%
Infectious	171[b]	2.0	11[c]	1.1	182	1.9
Neoplasms	114[c]	1.4	34[b]	2.9	148	1.5
Endocrine	152	1.8	23	2.0	175	1.8
Blood	10[c]	0.2	5[b]	0.6	15	0.2
Mental disorders	471[c]	5.7	96[b]	9.0	567	5.9
Nervous system	536	6.3	58	5.2	594	6.2
Circulatory	404[b]	4.8	37[c]	3.5	441	4.6
Respiratory	237[c]	2.8	47[b]	4.5	284	3.0
Digestive	997[b]	11.6	74[c]	6.6	1,071	11.2
Genitourinary	333[c]	3.9	101[b]	9.0	434	4.5
Skin	239	2.8	32	2.9	271	2.8
Musculoskeletal	1,597	18.8	208	18.3	1,805	18.8
Congenital	48	0.5	9	0.7	57	0.6
Ill defined	877[c]	10.5	156[b]	14.4	1,033	10.8
Injury	2,140[b]	25.2	176[c]	16.4	2,316	24.2
Supplementary	148[c]	1.7	35[b]	3.0	183	1.7
Total	8,474	100.0	1,102	100.0	9,576	100.0

ICD-9 diagnoses associated with childbirth, diseases of the male genital organs, inflammatory disease of female pelvic organs, and other disorders of the female genital tract were excluded.

[a] $\chi^2 = 201.90$, $df = 15$, $p < 0.001$.

[b] Adjusted standardized residual was more than +2.0.

[c] Adjusted standardized residual was less than −2.0.

DNBI distributions also differed between the phases of OIF. The initial, intense combat experience, as well as the constant movement of convoys, may have contributed to the higher proportion of mental disorders and nonbattle injuries during OIF-1. However, diseases of the musculoskeletal system, such as injuries due to overuse and chronic pain, were expectedly more prevalent during OIF-2. In fact, musculoskeletal problems accounted for one in five DNBI hospitalizations during this time period.

Although this analysis provides important information regarding operational, gender, and service-specific differences in injury and illness distributions, there are limitations. Only hospitalization data were represented in this study, which include casualties who required medical care at a level III treatment facility due to more serious injury or illness. As such, these data may not reflect distributions of sick call or surveillance reporting systems from forward-deployed medical treatment facilities. The reporting tools used in this study (i.e., TRAC2ES and JPTA) are primarily used for tracking casualties and do not provide a denominator or population at risk. Furthermore, the reliability and validity of the diagnostic methodology and characteristics of medical providers in theater is unknown, and determining the accuracy of the ICD-9 data was outside the scope of this study. However, as the only diagnostic information provided by these reporting tools, ICD-9 data may serve as the best proxy measure to incorporate into current and future HSS modeling and simulation applications.

Despite these limitations, the findings demonstrate that casualty medical care resource planners should evaluate the differences in ICD-9 distributions for both WIA and DNBI casualties by operational phase, branch of service, and gender. Furthermore, methodologies that estimate scenario-specific patient streams should be modified to account for these distinctions to eliminate medical resource shortfalls such as the number of beds needed or the proper mix of medical specialists to treat the casualties. Together

TABLE VII. Distribution of DNBI Casualties by Gender and ICD-9 Diagnostic Category during OIF-1 and OIF-2

	OIF-1				OIF-2			
	Men		Women		Men		Women	
ICD-9 Category	No.	%	No.	%	No.	%	No.	%
Infectious	7	0.9	0	0.0	164	2.1	11	1.0
Neoplasms	3	0.4	4	3.7	111	1.4	30	2.6
Endocrine	8	1.1	2	1.8	144	1.8	21	1.8
Blood	1	0.1	1	0.9	9	0.1	4	0.4
Mental disorders	54	7.1	12	11.0	417	5.3	84	7.4
Nervous system	33	4.4	5	4.6	503	6.4	53	4.7
Circulatory	30	4.0	2	1.8	374	4.8	35	3.1
Respiratory	29	3.8	5	4.6	208	2.7	42	3.7
Digestive	64	8.4	2	1.8	933	12.0	72	6.3
Genitourinary	40	5.3	12	11.0	379	4.9	184	16.2
Pregnancy	0	0.0	13	11.9	0	0.0	38	3.3
Skin	20	2.6	0	0.0	219	2.8	32	2.8
Musculoskeletal	82	10.8	7	6.4	1,515	19.4	201	17.6
Congenital	8	0.8	0	0.0	42	0.5	9	0.8
Ill-defined	61	8.0	14	12.8	816	10.5	142	12.5
Injury	312	41.2	26	23.9	1,828	23.4	150	13.2
Supplementary	8	1.1	4	3.7	140	1.8	31	2.7
Total	758	100.0	109	100.0	7,802	100.0	1,139	100.0

Note: χ^2 tests were excluded due to insufficient cell counts.

TABLE VIII. Distribution of Nonbattle Injuries among DNBI Casualties by Gender during OIF[a]

Nonbattle Injury	Men		Women		Total	
Category	No.	%	No.	%	No.	%
Burns	74	5.1	9	3.5	83	3.6
Dislocations	178	5.0	17	4.2	195	4.3
Fractures	721	16.6	54	17.9	775	17.8
Heat	37	1.8	5	1.1	42	1.2
Sprains/strains	649	18.0	48	19.8	697	19.7
Open wounds	304	10.5	23	11.6	327	11.5
Other	177	10.2	20	7.6	197	7.8
Total	2,140	100.0	176	100.0	2,316	100.0

[a] $\chi^2 = 5.62$, $df = 6$, $p = 0.47$.

with the estimated counts of casualties, patient streams are the impetus of projecting the resources needed to sustain the HSS.

Future research should compare various command elements, which will provide more insight on the differences between ICD-9 category distributions. Future studies should also attempt to examine the accuracy of the ICD-9 data from TRAC2ES and JPTA by comparing it with data collected and coded by registries such as the Navy-Marine Corps Combat Trauma Registry.[14] The Navy-Marine Corps Combat Trauma Registry, although primarily consisting of Marine casualties and including only patients initially treated at level I and II Navy-Marine Corps facilities, uses professional nurse coders to code injuries and illnesses which allows for the identification of possible systematic biases and assessments of reliability and validity. Diagnostic reporting procedures and guidelines may need to be adopted by TMIP-J to address these issues in their reporting tools. More work is needed to identify wounding patterns associated with specific causative agents and to identify the populations at risk, which are necessary for calculating incidence and prevalence of the disease or injury entities.

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14. ABSTRACT (maximum 200 words)

The objective of this study was to evaluate the distributions of wounded in action (WIA) and disease and nonbattle injury (DNBI) casualties during the Operation Iraqi Freedom Major Combat Phase (OIF-1) and the Support and Stability Phase (OIF-2). A retrospective review of hospitalization records was conducted. Chi-square tests were used to assess the distributions of casualties by phase of operation, casualty type, branch of service, gender, and ICD-9 diagnostic category. Of the 13,988 casualties identified for analysis, 3,356 were WIA and 10,632 were DNBI. Overall, the proportion of WIA was higher during OIF-1 (32.7%) than OIF-2 (22.9%). U.S. Marines had a higher proportion of WIA and nonbattle injuries than all other services. Although overall DNBI distributions for men and women were statistically different, their distributions of types of nonbattle injuries were similar. Identifying differences in injury and illness distributions by characteristics of the casualty population is necessary for military medical readiness planning.

15. SUBJECT TERMS
Operation Iraqi Freedom, wounded in action, disease and nonbattle injury

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